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COMPLETE SPECIFICATION.

Improvements in or relating to Filters.

I, RONALD JOHN STEVENS, of "Dunoon", Coombe Lane, Kingston Hill, Surrey, a British Subject, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to filters for fluids (gaseous or liquid) of the type comprising a pluarlity of layers of metal in lamina, sheet or plate form held together face to face in a pile, pack or coil, the surface of at least one of the layers or in the case of a pile, pack or coil comprising more than two layers of at least one of each pair of adjacent layers of the pile, pack or coil, having in it or as the case may be on it a number of depressions or projections which form at the interface of the layers fine flow passages for the fluid to be filtered extending across said interface, in which flow passages the filtering takes place, said depressions or projections having been formed by an etching or electrolytic process with the use of a masking pattern applied to the surface of the metal to form the component layers of the filter, the masking pattern being composed of a substance capable of mechanically insulating said surface from the etching liquid or as the case may be the electrolyte except for portions thereof determined as regards size, shape and position by the design of the pattern, the masking pattern being afterwards removed and the effect of the etching or electrolytic process being to form depressions as aforesaid is the surface or (in the case of use of an electrolytic process resulting in addition of metal to the surface) projections as aforesaid thereon.

According to the invention, such a filter is characterised by the provision of inflow and outflow lanes for said fluid to be filtered extending (i.e. lengthwise of the lane, in contrast to depthwise thereof) across the interface or interfaces of the layers of the pile, pack or coil, the arrangement being such that the fluid flows into the flow passages by way of the inflow lanes and out of the flow passages by way of the outflow lanes.

In this way a construction is provided in which it is possible (a) to predetermine with great accuracy the "aperture size" of the filter, by which is meant, for any given fluid to be filtered, any given viscosity of said fluid and any given pressure thereon at the inlet of the filter, the effective through-way area of the filter for the flow of the fluid therethrough, and therefore the rate of flow through the filter of a given fluid having a given viscosity and subject to a given pressure applied to it at the inlet of the filter, and (b) to increase many times and practically to any extent desired said aperture size (as compared with a case where as hitherto the filter has been devoid of inflow and outflow lanes extending (lengthwise of the lane) across the interface or interfaces of the component layers of the filter) to suit the particular requirements of the filter.

For the purposes of this Specification the term "etching process" means any process involving removal of metal purely by chemical action, and the term "electrolytic process" means any process involing removal or additions of metal by electrolytic action.

The size cross-sectionally of the flow passages of the filter may vary widely, down to an extremenly small size, particularly in a case where, as is generally preferred the passages are formed by an electrolytic process since in such a case by suitably controlling the current flow (as to amperage and/or direction) it is possible to produce passages of the order of only a few microns with extreme accuracy.

The masking pattern may be composed of

any suitable material for the purposes of the invention, e.g. printers ink, of the variety used for the preparation of etched metallic labels, which as is known is non-conductive (in the electrical sense) or only slightly so and is substantially inert to both alkalies and acids. The ink used may be of quick drying characteristic owing to the incorporation in it of volatile ingredients and, if desired, it may be devoid of pigment.

The pattern may be applied to the surface to be etched either by hand or by mechanical means. Conveniently it is printed on, with the use of a printing block or roller or by a lithographic process. Alternatively it may be applied photographically.

The component layers of the filter may if desired be backed with a backing layer. For example, they may consist of a thin film of metal applied, by evaporation or otherwise, to the surface of a non-metallic carrier sheet, said thin film having been etched or electrolytically treated subsequently to its application to the carrier sheet.

The inflow and outflow lanes may extend completely through the component layers of the filter, the inflow and outflow lanes being in the form of slots extending completely through the layers. In this event, the arrangement may either be one in which the inflow lanes, and similarly the outflow lanes, of two or more successive interfaces of the filter pile, pack or coil are in line with one another, with the result that in this case the fluid enters all of the interfacial spaces (each interfacial space being made up of a multiplicity of "flow passages" as hereinbefore referred to) between the layers (flowing thereinto from the inflow lanes) simultaneously and similarly leaves all of these spaces (flowing therefrom into the outflow lanes) simultaneously; or one in which the same lanes are at the same time outflow lanes with respect to one interfacial space and inflow lanes with respect to the next, the inflow lanes of two or more successive interfaces of the filter pile, pack or coil being in this sense staggered with respect to the outflow lanes of these interfaces, with the result that in this case the fluid enters the successive interfacial spaces and similarly leaves the same one after the other. In the first case the fluid may be regarded as having a parallel-flow course and in the second a series-flow course. If desired, a combination of these two type of course may be employed.

In carrying out the electrolytic process care should be exercised to equalize the current distribution. Two simple methods for accomplishing this are described later.

If desired, both in the case of use of an etching process and also in the case of use of an electrolytic process, a large sheet of metal may be printed with a plurality of masking patterns, or the equivalent thereof in the form of a repetition pattern, for the formation of a corresponding plurality of filter layers or filter layer coil strips, and the large sheet thus printed may then be submitted to the etching or electrolytic treatment for the formation of all of the layers or strips in the one operation, it being understood, of course, that, following the etching or electrolytic treatment and the removal subsequently of the masking pattern or patterns, the sheet would, if necessary, be cut up into sections to form the individual layers or coil strips to be produced.

Certain types of filter require that the pores (flow passages) shall be vary fine, e.g. of the order of a few square microns in cross-sectional area. An etching or electrolytic process, whilst giving highly consistent results, this being particularly true in the case of the electrolytic process, is limited by the consideration that even with the use of a printing operation for the deposition of the masking pattern upon the filter layer forming member, there is a practical limit to the degree of fineness of the pattern that can be employed. Thus, whilst it is relatively easy by means of a printing operating to produce a pattern exposing 0·005 inch diameter areas on a solid background, it is generally impossible by such means to produce a pattern exposing areas of considerably smaller diameter than this, e.g. areas of the order of 0·0005 inch diameter.

In such a case, a relatively thick sheet to form the filter layer forming member is employed, e.g. a sheet of the order of ·006 inch in thickness, and following the etching or electrolytic treatment of the sheet, which treatment is effected with the use of a masking pattern exposing areas of the smallest practicable diameter, the sheet is rolled to a smaller thickness dimension, which has the effect of closing up the flow passages which have been formed by the etching or electrolytic treatment to a smaller size. In this way practically any desired order of fineness of the flow passages of the filter may be attained, since the rolling process may be repeated any number of times. Thus, in the case of a sheet initially of a thickness dimension of 0·006 inch and the use of a masking pattern exposing areas of a diameter or width dimension of 0·003 inch, the sheet, following the etching or electrolytic treatment and, of course, the removal of the masking pattern, may be rolled down to a thickness dimension of 0·001 inch, in which case the flow passages which have been formed in the sheet by the etching or electrolytic treament will be closed up to a width dimension of the order of 0·0003 inch or 7·5 micron, which closing up involves a substantial reduction of the cross-sectional area of the passage, due partly to the lessening

of the width of the passage and partly due to the reduction of the depth thereof.

Such reduction of the size of the flow passages may be advanced further, if necessary or desired, by electro deposition of metal on the etched or electrolytically treated sheet prior to or during the rolling operation, such electro deposition having the effect of thickening the sheet over the entire surface thereof and thereby reducing the width and depth dimensions of the flow passages therein. In this way, even without the rolling out of the etched or electrolytically treated sheet, flow passages may be obtained whose width and depth dimensions are as small as the order of 1 micron.

The invention will now be further described with reference to the accompanying drawings, which are to a certain extent diagrammatic and are appended rather to illustrate the general principles of the invention than the constructional details thereof.

In these drawings:—

Figure 1 is a fragmentary cross-section through a filter in accordance with the invention in the from thereof according to which a length of sheet metal is treated by an etching or electrolytic process in the manner hereinbefore described so as to produce upon one face of the sheet a number of closely spaced fine section grooves, depressions or other cavities or (with the use of an electrolytic process) ribs, bosses or other raised portions, after which and following, of course, the removal of the masking pattern, the sheet is tightly wound to the form of a coil, the cavities in the sheet or as the case may be the raised portions thereof forming with the back (untreated face) opposite to it of the adjacent layer of the coil a multitude of minute flow passages for the fluid along which the latter flows in making its way through the filter. In the Figure several layers of the coil appear, marked respectively E, F and G, the flow passages being marked H.

Figures 2 and 3 are fragmentary cross-sections through the filter coil showing how, in accordance with the present invention, the interfacial spaces between the layers E, F, G are connected by "lanes" R as hereinbefore referred to extending (depthwise of the lane) through the layers and by way of which the fluid first gains access to and then leaves said interfacial spaces in flowing through the filter, Figure 2 illustrating the case where the fluid flows in "parallel-flow" course while Figure 3 shows the case where the fluid flows in "series-flow" course.

The form of the flow passages may vary widely. Figure 4 illustrates a few possible forms by way of example.

As shown in this Figure, the passages may follow a winding path as illustrated at I or J or K or L or again at M, the case illustrated at M being one in which the winding passages are crossed and placed in communication with one another by passages *m* extending lengthwise of the sheet and therefore circumferentially of the coil layer. Alternatively, the passages may take the form of diagonally crossing lines as illustrated at N. According to another form the passages may be constituted by the spaces between rows of raised dots O, or according to a further form by grooves extending diagonally across the sheet, or obversely, by the spaces between ribs extending in this manner thereacross, as illustrated at P.

Figures 5 and 6 are respectively an end view and side elevation of a support suitable for a filter of the coil form above described.

As shown in these Figures, the support comprises two mutually complementary semi-circular frame halves 1, 2 bolted together by bolts 3 extending through bosses 4 in the frame halves. Bolted to the rear face of the frame halves is a circular grill 5, the bolts by which this grill is secured to the frame halves being marked 6. The coil filter (not shown in these Figures) is disposed within the cylindrical space bounded by the inner peripheral surfaces of the axial flanges of the frame halves 1, 2 and it is firmly supported against the pressure of flow of the fluid in course of being filtered by the grill 5, the direction of said flow being indicated by the arrow 7 in Figure 6. It is to be understood, however, that the support may take any other convenient form.

Figure 7 is a plan view of a filter of cylindrical pack form, the inflow and outflow lanes for the fluid being disposed radially of the filter layers. In the filter shown there are two series of flow lanes in each layer of the pack forming the filter. One of these series is marked S and the other T and the lanes of the respective series are in coincident relation to one another, similarly to the arrangement illustrated in Figure 2, with the result that the interfacial spaces between successive layers of the filter and interconnected with one another through the depth of the pack of layers by the flow lanes S, T. In other words, considering any given interfacial space between a pair of adjacent layers, the series S or the series T of flow lanes extending through one of the layers of the pair form in effect inflow lanes leading to the interfacial spaces ad the other, T or S as the case may be, outflow lanes leading therefrom, the arrangement being therefore one in which the fluid has a "parallel flow" course through the filter as hereinbefore remarked.

It will be understood that in a construction in accordance with Figures 2 and 7 the terminal (e.g. top and bottom) layers of the pack should have, as shown, only half as many lanes extending through them as each

of the intervening layers, the lanes in one of the terminal layers being aligned with the common (aligned) inflow lanes and the lanes in the other terminal layer being aligned with the common outflow lanes.

The diameter and thickness dimensions of the layers and the total numbers of layers forming the filter may be varied widely to suit the general requirements of the filter. By way of example, the thickness dimensions of the layers may be of the order of 0·0015 inch, or more as required.

It will be seen that in the particular case illustrated in Figure 7, each of the series, S, T of flow lanes, which are in the form of rectilinear slots, comprises 16 slots. Therefore, with respect to any given interfacial space between a pair of adjacent layers, there are 16 inflow lanes and 16 outflow lanes, e.g., each one inch long.

By way of example, the sheet metal from which the layers are formed may have a thickness dimension of 0·001 inch and the depth of the flow passages which are formed in the layers by the etching or electrolytic treatment of said sheet metal may be 4 micron and the width of the flow passages 0·005 inch. In such a case there will be approximately 1000 layers per inch depth of the pack and therefore approximately 16,000 inches of developed length of the slots S, T per inch depth of the pack. Along each of these 16,000 inches of developed length there would be, assuming a reasonable figure of 200 flow passages per inch, a total cross-sectional flow passage area of 200×4 micron $\times 0{\cdot}005$ inch, which would give per inch depth of the pack $200 \times 0{\cdot}005 \times 0{\cdot}00015$ ($=4$ micron) $\times 16{,}000 = 2{\cdot}4$ square inches of total cross-sectional flow passage area in the filter.

This will demonstate by way of example how with a filter constructed as illustrated in Figure 7 a very high porosity (aperture size) is obtainable. Similar results are obtainable with a construction in which the pack is say rectangular instead of circular and the inflow and outflow lanes (slots) are parallel to one another.

It will also be appreciated that the pack or coil form of filter is capable of withstanding very high flow pressures upon it, particularly if it is supported against such pressures by a grill or the like in the manner hereinbefore described.

With the use of certain masking patterns it may be difficult to obtain a uniform measure of electrolytic action upon the sheet metal to form the layers of the filter due to the fact that as the electrolytic treatment proceeds voids are formed in the sheet, which in turn obstruct the current flow to other parts thereof.

This difficulty may be avoided by feeding the combination comprising the sheet and the masking pattern in position upon it progressively through the electrolytic bath, for example with the use of a guide roller dipping into the bath, or fully immersed therein, and around which, over the lower portion of the periphery of the roller, the combination passes as, with the rotation of the roller, it is traversed into, through and out of the bath.

According to an alternative method of ensuring uniform electrolytic action over the whole area of the filter layer forming sheet, an arrangement as illustrated in Figures 8 and 9 may be employed.

As shown in these Figures, of which Figure 9 is an enlarged fragmentary view of Fig. 8, the sheet which is marked V and of course has the masking pattern, marked *v*, in position upon it, has applied to the rear face of it a layer W of electrical insulating material with holes *w* in it at distributed points with respect to the total area of the sheet V. The combination comprising the sheet V, the masking pattern *v* and the insulating layer W is pressed against a rigid carbon or metal electrode X constituting one of the electrodes of the electrolytic bath, the other electrode thereof being marked Y. The said combination is pressed against the electrode X by means of a number of spring loaded rods Z of electrical insulating material, the respective positions of which can be varied at will or as required, according to the design of the masking pattern *v*. In this way electrical contact may be established as between the electrode X and the sheet V at a number of points so distributed as to ensure substantially complete uniformity of electrolytic action over the entire area of the sheet to be acted upon.

What I claim is:—

1. A filter for fluids (gaseous or liquid) of the type described, characterised by the provision of inflow and outflow lanes for the fluid to be filtered extending across the interface or interfaces of the layers of the pile, pack or coil, the arrangement being such that the fluid flows into the flow passages by way of the inflow lanes and out of the flow passages by way of the outflow lanes.

2. A filter as claimed in Claim 1, wherein at least some of the lanes are in the form of slots extending completely through the thickness of the layers.

3. A filter as claimed in Claim 2, wherein the arrangement as regards the inflow and outflow lanes is such that the fluid flows through the filter in parallel-flow course.

4. A filter as claimed in Claim 2, wherein the arrangement as regards the inflow and outflow lanes is such that the fluid flows through the filter in series-flow course.

5. A filter as claimed in Claim 2, wherein the arrangement as regards the inflow and

outflow lanes is such that the fluid flows through the filter partly in parallel-flow course and partly in series-flow course.

6. A filter as claimed in any of the preceding claims housed within a support therefor incorporating a grid or like member in rear of the filter adapted to support the latter against the pressure of the fluid as it flows through the filter.

7. A filter for fluids (gaseous or liquid) constructed, arranged and adapted to operate substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 11th day of February, 1952.

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PROVISIONAL SPECIFICATION.

Improvements in or relating to Filters.

I, RONALD JOHN STEVENS, of "Dunoon", Coombe Lane, Kingston Hill, Surrey, a British Subject, do hereby declare this invention to be described in the following statement:—

Filters are at present built up by compacting or otherwise assembling in convenient form a mass of natural or synthetic material, but it is difficult to produce in this way a filter having an accurately predictable porosity.

According to the invention advantage is taken, in the manufacture of a filter, of the fact that the amount of metal deposited on or removed from an electrode by electrolysis can be accurately calculated.

The invention provides a method of constructing a filter, which includes the steps of applying to a sheet of metal a resist pattern of a material which will protect the metal beneath it from electrolytic action, the pattern leaving thin strips of metal unprotected, subjecting the sheet to electrolytic action to remove a thin layer of metal from, or deposit a thin layer of metal on, the unprotected portions of the sheet and removing the resist pattern. In this way I obtain a metal sheet having on the treated surface a series of fine grooves, or a series of thin upstanding ribs, of accurately determined size. Such sheets may then be assembled to produce a filter having pores of known size determined by the time to which the sheet has been subjected to electrolytic action.

The resist pattern is most conveniently applied to the sheet by printing from a block or roller, and printer's ink is a suitable resist material, although I may use any other material which will have the required protecting effect and can be applied to the sheet by ordinary printing techniques.

Preferably the pattern consists of a series of parallel lines of ribs and the width of the lines may be as small as ·001 in. and the spacing between them also as small as ·001 in. The depth of the layer of metal removed from or deposited on the unprotected areas of the sheet may be as small as 10 microns.

A stack of sheet treated in this way may be built up to form a filter, the treated surface of each sheet abutting against the plane untreated surface of the next sheet. As an alternative, a filter of circular section may be produced by subjecting a relatively long sheet of metal to the electrolytic treatment and then coiling the treated sheet. This has the advantage that the filter may readily be cleaned after uncoiling the sheet.

In either case, the stack or coil will, in use as a filter, be supported in a suitable holder.

The thickness of the metal sheet may be of any convenient value and, if desired, the metal may be in the form of a thin film applied, by evaporation or otherwise, to a suitable non-metallic carrier sheet.

As an alternative to the above-described procedure, I may, in the case where the sheet consists wholly of metal, apply a resist pattern which leaves exposed only small "dots" of metal and subject the sheet to electrolysis so as to remove altogether the unprotected portion of the sheet. The resulting sheet will then have fine holes of size determined by the resist pattern and may be used as such as a filter. Alternatively I may superpose a stack of such perforated sheets to form the filter, if desired with the holes in the sheets relatively staggered.

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721,592 COMPLETE SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.